

CONTRIBUTIONS TO THE TRADESCANTIA PROBLEM

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With plate 45 and three text figures

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INTRODUCTION

THE GENUS *Tradescantia* is as taxonomically difficult as it is cytologically superb. On the one hand its fugitive flower parts render herbarium specimens a poor record of the living plant; on the other those very phenomena (fragmentation, polyploidy, ring-formation) which attract the cytologist, produce intricate and puzzling relationships between species. It would remain a difficult genus to monograph if its floral characteristics were as well preserved in herbarium specimens as are those of the genus *Aster* for instance. Monographing *Tradescantia* from herbarium specimens alone would indeed be almost like working with a collection of *Compositae* from which the flowerheads had been removed.

Yet though the genus is an extraordinarily difficult one from the orthodox taxonomic viewpoint, it has much to recommend it for cyto-genetic studies. It grows easily from seeds or transplants and can withstand all sorts of mistreatment. It has a long-blooming period and artificial pollinations are not difficult to make. The chromosomes are enormous (they can sometimes be counted under low power) and are readily studied in smear preparations. Both tetraploid and diploid species and varieties occur in nature, and white, blue, and pink forms are already available for genetical analysis. It is by all odds one of the most promising native American genera for cyto-genetic investigations. Yet fundamental conclusions as to the evolutionary importance of cytogenetic phenomena will not be possible until they can be viewed against a background of sound morphological and taxonomical research.

If those geneticists and cytologists who are studying *Tradescantia*

would record, in addition to cytological details, the exact source of their material, and the nature of the pubescence on the leaves, on the sepals, and on the ovary, it would be possible to apply their findings to other problems besides those of chromosome structure.

TRADESCANTIA IN THE ST. LOUIS REGION

The following paper reports a preliminary cytological and genetical analysis of the *Tradescantias* of the Saint Louis region. It is a "report of progress" in an attempt to describe these species as they occur in that region, to evaluate the forces which have produced them, and to measure the evolutionary processes which are taking place within them at the present time.

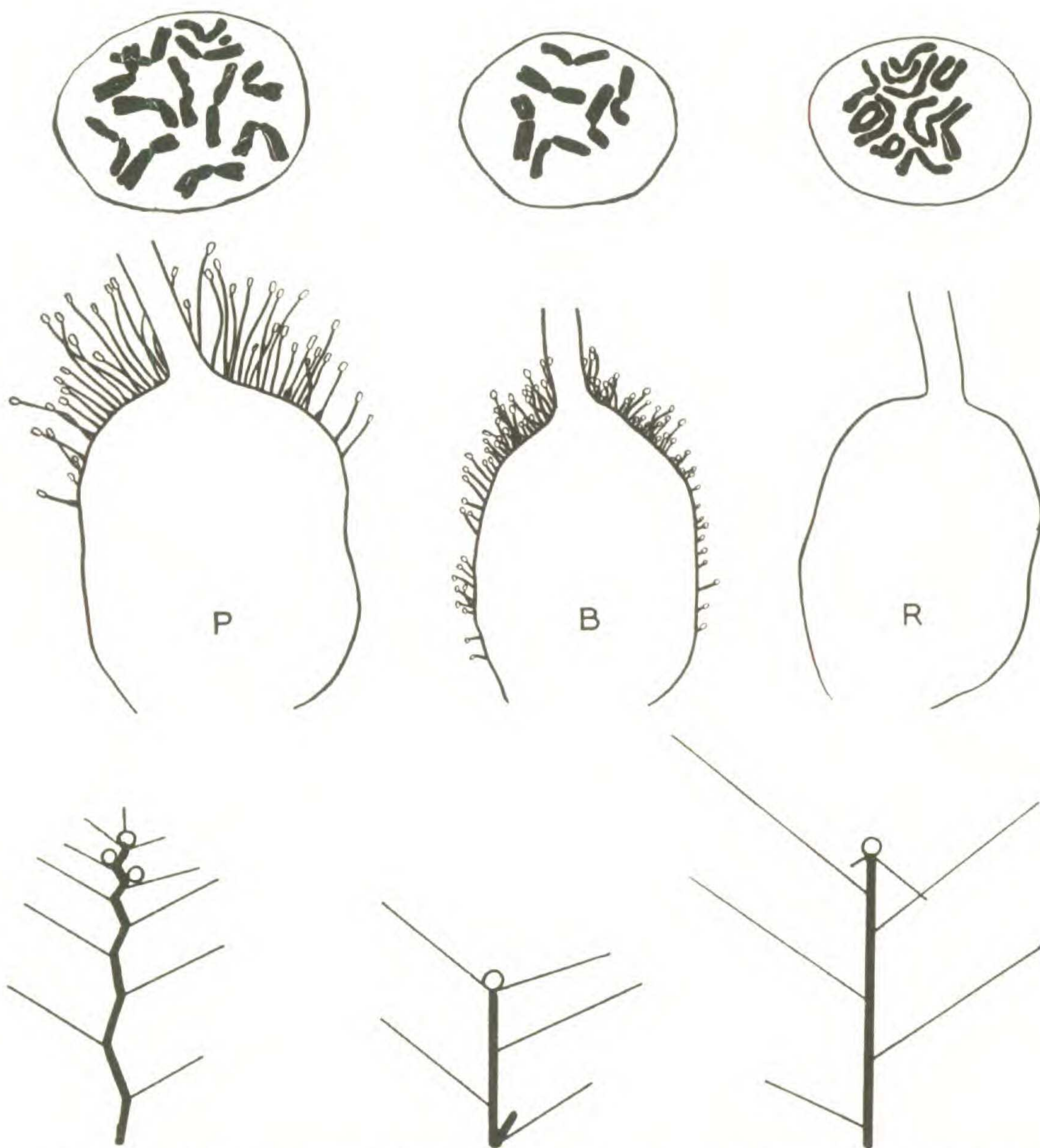


Figure 1. A comparison of the chromosome complement, the ovary, and the general habit of *T. pilosa* (left), *T. bracteata* (middle), and *T. reflexa* (right). Complete explanation in the text.

There are at least three species of *Tradescantia* in eastern Missouri. There may be more; there cannot possibly be fewer. If there eventually prove to be ten or twenty species they will even then fall into three groups. These three groups are separated from each other morphologically, ecologically, and cytologically. We are identifying them provisionally as *Tradescantia pilosa* Lehm., *T. reflexa* Raf., and *T. bracteata* Small. There are other *Tradescantias* in the state but we did not find them in the area covered by this study.

The outstanding differences between the three species are shown, somewhat diagrammatically, in figure 1. The middle row shows camera lucida drawings of the ovary and its pubescence. The lower row, reduced to scale from actual specimens, shows leaf size and number, length of node and number of nodes, etc. The upper row shows the gametic chromosome complement from camera lucida drawings of smears of pollen grain mitoses.

Tradescantia reflexa

Tradescantia reflexa is by far the commonest of the three species. It is tall and slender, glaucous throughout, with narrow, reflexed bracts. The ovary is completely glabrous or at most bears two or three tiny hairs at the base of the style. At Eureka, Missouri it was found on the limestone "glades" of the region. These are dry, stony hillsides with a semi-arid flora. They were apparently in this area the original home of the species, from which it has spread to railroad rights of way, dump-heaps, and the like. There was no apparent morphological or cytological difference between these "glade" populations and those along the railroad tracks.

Several of the colonies included variants, which had they not been connected with the normal type by a complete series of intermediates, might have been considered as taxonomically distinct. At Algonquin Station, Webster Groves, there were several very dwarf plants less than a foot high, but there were also a number of intermediates between these dwarfs and the rest of the colony. At Hamburg, Missouri, the opposite extreme was found, for several of the plants in this colony measured well over six feet in height. The most outstanding variation was seen at Hillsboro, Missouri, along a sandstone outcrop. The plants of this colony were all characterized by scattered hairs on the calyx in addition to the normal tuft usually found in *T. reflexa*. They were also differentiated by being early-flowering and it is possible that they are varietally distinct from the other plants of *T. reflexa* studied. For the present we have included them under *T. reflexa*. It is quite possible that they may be the result of hybridization with *T. bracteata*. In all of the above cases,

these peculiar forms were examined cytologically (both P M C and pollen divisions) and showed no divergences in chromosome numbers. Nineteen plants were recorded, as shown in Table 1. All were tetraploids ($2n = 24$). Many other plants were examined, and their chromosome numbers determined, but no definite record was made. Unfortunately the only plant showing a fragment chromosome was among these unrecorded individuals and it is not possible to say from which locality it came.

In spite of its variability, *T. reflexa* remains an easily recognizable unit over a very wide area. Colonies in south-western Michigan (Schoolcraft) and in southern Illinois (Ullin) seemed essentially the same as those examined in Missouri. The following collections available in herbaria represent plants morphologically similar to those we studied cytologically: *Lansing*, no. 3121, Mansfield, Mo.; *Lansing*, no. 3037, Cedar Gap, Mo.; *Ridgway*, no. 2116, Olney, Ill.

Examination of reduction divisions showed that *T. reflexa* was not only a tetraploid but was practically an auto-tetraploid. There was a very strong tendency for the chromosomes to conjugate in sets of four, the number of quadrivalents per PMC varying from 0 to 6. A count of ten PMC from a single smear of *T. reflexa* gave the following frequencies:

No. of times observed	No. of II's	No. of IV's
1	0	6
2	2	5
2	4	4
1	6	3
3	8	2
1	10	1

In the material examined the separation of quadrivalents was not at random. There was a very strong tendency (about 10 to 1) for adjacent chromosomes to pass to opposite poles. The data are consistent with the hypothesis that *T. reflexa* is an auto-tetraploid in which there is a slight differentiation between the two diploid sets of which it is made up. Its chromosome complement might be diagrammed as follows:

AA' BB' CC' DD' EE' FF'
AA' BB' CC' DD' EE' FF'

Tradescantia bracteata

As it occurs in Missouri this is a dwarf species seldom over a foot (3 dm.) in height. The ovary is covered with short glandular hairs (fig. 1). The flowering period is comparatively short and as the seed ripens the leaves die down and the plants pass through the summer in a semi-dormant condition. The flowers are more bril-

liant in color than those of *T. pilosa* or *T. reflexa*. Pink-flowered plants and blue-flowered plants are usually found growing together and albinos are not uncommon. The following collections represent material essentially similar to that which we studied cytologically: *Bush*, no. 684, Watson, Mo.; *Bush*, no. 336, Grandin, Mo.; *Davis*, no. 4403, Whiteside, Mo.

Tradescantia bracteata grows in abundance on rich black soil along roadsides and in wet meadows in the bottomland of the Mississippi River at Portage des Sioux, Missouri. The chromosome numbers of six plants from this locality were determined as is indicated in Table 1. All were diploids ($2n = 12$). One had a small fragment chromosome.

Tradescantia pilosa

This is by far the most distinct of the Missouri Tradescantias. In the St. Louis area it occurs only in shady situations, usually in rich sandy soil at the base of sandstone cliffs or in pockets on the face of the cliff. Since sandstone areas in eastern Missouri are mainly confined to a long narrow outcrop of St. Peter sandstone, *T. pilosa* is an uncommon species there. It was found in abundance

TABLE 1

Chromosome Numbers of wild-growing Tradescantias from eastern Missouri.
(Including a few plants of *T. reflexa* from outside that region.)

SOURCE	P M C	POLLEN GRAIN MITOSIS
<i>T. reflexa</i>		
Hillsboro, Mo.....	n = 12	—
Hillsboro, Mo.....	—	n = 12
South Webster, Mo.....	—	n = 12
Eureka, Mo.....	n = 12	n = 12
Hamburg, Mo.....	—	n = 12
Hamburg, Mo.....	—	n = 12
?, Mo.....	—	n = 12 + f
Antonio, Mo.....	—	n = 12
Ullin, Ill.....	—	n = 12
Ullin, Ill.....	—	n = 12
Ullin, Ill.....	—	n = 12
Ullin, Ill.....	—	n = 12
La Crosse, Wis.....	—	n = 12
Schoolcraft, Mich.....	n = 12	n = 12
Schoolcraft, Mich.....	—	n = 12
Schoolcraft, Mich.....	—	n = 12
Schoolcraft, Mich.....	—	n = 12
<i>T. pilosa</i>		
Hermann, Mo.....	n = 12	—
Hermann, Mo.....	—	n = 12 + f
Marthasville, Mo.....	n = 12	—
Marthasville, Mo.....	—	n = 12
<i>T. bracteata</i>		
Portage des Sioux, Mo.....	n = 6	n = 6
Portage des Sioux, Mo.....	—	n = 6 + f
Portage des Sioux, Mo.....	—	n = 6
Portage des Sioux, Mo.....	—	n = 6
Portage des Sioux, Mo.....	—	n = 6
Portage des Sioux, Mo.....	—	n = 6

at Marthasville, Hermann, Ashland, and Winfield, Mo. The following collections, available in many of the larger herbaria, represent material essentially similar to that which we studied cytologically: *Eggert*, St. Louis, Mo.; *Davis*, no. 3604, Hannibal, Missouri; *Eggert*, Hematite, Mo.; *Palmer*, no. 34,802, Pontiac, Missouri.

In general aspect *T. pilosa* is entirely different from any other Missouri Tradescantia. The stem is tall and zig-zag, the entire plant is sparingly pilose. The flowering season is late (July to August). The ovary bears long scattered hairs with relatively small glands at their tips. (Fig. 1). The chromosome numbers of 4 plants were determined; as reported in Table 1. All were tetraploids ($2n = 24$).

A COMPARISON OF VARIATION IN DIPLOID AND TETRAPLOID SPECIES

As has been reported above, *T. reflexa* (in Missouri, Illinois, Wisconsin, and western Michigan) was found to be a tetraploid species. *T. bracteata*, on the other hand, was a diploid. That is, *T. bracteata* like most normal animals and plants had its chromosomes in sets of twos. Those of *T. reflexa* on the other hand, were in sets of fours. This tetraploid condition should have a very marked effect upon the nature of individual differences in the two species. It should increase not only the proportion of intermediates but the number of intermediate types. An example may make this more clear.

Let us consider the simplest possible case, a single factor difference, albinism, for example, as it might be expected to operate in the diploid *T. bracteata*, on the one hand, and in the tetraploid, *T. reflexa* on the other. The inheritance of albinism in Tradescantia, so far as we know, has not actually been studied but the circumstantial evidence from forms existing in nature is all in accord with the hypothesis that as in practically all other flowering plants it is due to a single recessive gene. If we represent the gene for albinism by *a*, and its normal allelomorph by *A*, an albino plant of *T. bracteata* will be of the genetical composition (*aa*) and a pure-breeding full-colored plant will be (*AA*). Crossing the two will give us a heterozygous F_1 (*Aa*) which, selfed or crossed *inter se*, will produce the familiar $\frac{1}{4}(AA)$ $\frac{1}{2}(Aa)$ $\frac{1}{4}(aa)$ in the second generation. That is, in the diploid species, as regards the gene for albinism, there can be only three possible genetic types, the pure albino (*aa*) the pure-breeding normal (*AA*) and the heterozygote (*Aa*).

In the tetraploid *T. reflexa*, on the other hand, a pure albino must have a gene for albinism in each of the four sets of chromosomes and will be of the genetic constitution (*aaaa*). A cross with a homozygous (true-breeding) full-colored individual (*AAAA*) will in the

second generation produce full-colored (AAAA), albinos (aaaa), and three genetically different types of intermediates (AAAa), (AAaa), and (Aaaa). Whereas, in the diploid there were only three possible genetic types, there will be five in the tetraploid.

TABLE 2
A comparison of a cross between albinism and color in a diploid and an autotetraploid.

	DIPLOID	TETRAPLOID
Color parent.....	AA	AAAA
Albino parent.....	aa	aaaa
First generation.....	Aa	AAaa
Second generation.....	{ AA....25%	AAAA.... 2.8%
	{ Aa....50%	AAAa....22.2%
	{ aa....25%	AAaa....50.0%
		Aaaa....22.8%
		aaaa..... 2.8%

The differences between the two examples are set out diagrammatically in Table 2. It will be seen that in the tetraploid second generation as compared with the diploid, there are (1) three kinds of intermediates instead of one, (2) a much higher proportion of intermediates (94% instead of 50%). This will result in the tetraploid being tremendously more variable (using the word in its biological sense). In our hypothetical case of albinism in a population breeding at random and with, as is usually the case, the full-colored forms somewhat more variable than the albinos, we may expect in the diploid a large number of dark blues (AA), a large number of intermediates (Aa) and a few whites (aa). With exactly the same premises we will find in the tetraploids, very few dark blues and a large proportion of intermediates of various shades of blue and a very few pure albinos or none at all.

The same situation which has been outlined for albinism will apply to all the other genes; all will be present in sets of four instead of in sets of two. The change from pink flower to blue flower is apparently mainly due to a single factor. In a population of *T. bracteata* segregating for albinism and for pink we would expect to find only light and dark pink, light and dark blue, and white. In a similar population of *T. reflexa* we might expect to find blues, various intermediate magentas, and perhaps a few pinks, all in many degrees of color intensity.

These hypothetical deductions (which had been worked out from greenhouse material before we examined wild populations) are interesting because they agree exactly with what we actually *did* find. Large populations of *T. reflexa* were studied at five localities and *T. bracteata* was studied at two widely separated ones. The

data are summarized in Table 3. Those on flower color are difficult to present because of the variability of the tetraploids. In the diploid *T. bracteata* it was a simple matter to score the flowers as either pink or blue. Among the plants of *T. reflexa* any attempt at classification (aside from the extremely rare pure pinks) was extremely difficult and frankly artificial. In Table 3 an attempt is made to record the prevailing color types in each colony and the actual number of pure pinks or pure albinos. In another section of this paper one colony is taken up in as great detail as possible. The variation there reported is typical.

The number of genes segregating in a wild population is probably to be numbered by the thousands. For each of these the same situation will prevail which has been outlined in detail for those for pink and for albinism. The net result will be a tremendous increase in the total possible number of geneotypes in each population, and in the number and proportion of intermediates. Nearly every taxonomist who has worked with *T. reflexa* has commented on its peculiar variability. While the fact that it is a tetraploid (and practically an auto-tetraploid) does not explain all the peculiarities met with in this species, it is responsible for many of them.

Students of the group have commented on the fact that some species of *Tradescantia* customarily produce both pink-flowered and blue-flowered plants, while other species do not. Rose (1899) for instance, has included this characteristic in forming his specific descriptions. The cytological and genetical data reported above provide a logical explanation for this interesting difference.

TABLE 3
Variation in flower color in populations of *T. reflexa* and *T. bracteata*.

SPECIES	LOCALITY	PREVAILING FLOWER COLORS	NO. OF PURE PINKS	NO. OF PURE WHITES
<i>T. reflexa</i>	Algonquin, Webster Groves, Missouri	Blue, blue-magenta, magenta, magenta-pink	1	0
<i>T. reflexa</i>	S. Webster, Missouri	Blue, magenta-blue, magenta-pink	0	0
<i>T. reflexa</i>	Hamburg, Missouri	Dark-blue, blue, blue- magenta	0	0
<i>T. reflexa</i>	Hillsboro, Missouri	Dark-blue, blue	0	0
<i>T. reflexa</i>	Ullin, Illinois	Dark-blue, magenta, magenta-pink	0	0
<i>T. reflexa</i>	Schoolcraft, Mich.	Dark-blue, grey-blue, deep magenta, pale magenta	0	0
<i>T. bracteata</i> . . .	Portage des Sioux, Mo.	Bright blue 39, blue- magenta 1	14	0
<i>T. bracteata</i> . . .	Tama, Iowa	Blue 1100 ±	380 ±	6

VEGETATIVE REPRODUCTION IN TRADESCANTIA

Throughout his paper on the Tradescantiae, Darlington (1929) has assumed that *T. virginiana*¹ is propagated mainly, if not entirely, by vegetative means. He presents no experimental evidence for this conclusion other than to describe the cytological conditions which according to his theories make vegetative propagation obligatory. The following quotations are representative of his point of view: p. 254. "The fact that we have forms of *Tradescantia virginiana* with fragments that do not answer to the requirements of meiosis merely *emphasizes the unimportance of sexual reproduction in preserving this species.*"

P. 254. "*T. virginiana* itself has drifted into an evolutionary back water in which *vegetative propagation has become excessively important.*"

P. 278. "In *Tradescantia crassifolia* and *T. bracteata*, however, the various abnormalities must *reduce seed-production to negligible proportions if they reproduce themselves normally.*"

P. 279. "More recently Bush (1904) for example, has distinguished 18 different species from Texas alone; these would probably all resemble the types described cytologically [They do not. The seven that we have examined so far have been diploids.] and would be interfertile so far as they were fertile at all. It need hardly be said that none of them would be consistently true-breeding."

As will be demonstrated below this very logical theory is completely erroneous. We have not found the slightest scrap of evidence to support the thesis that tetraploid Tradescantias like *T. virginiana* and *T. reflexa* are dependent upon vegetative propagation. On the other hand we have found abundant evidence that it is even less highly developed among them than among the simple diploids from which they probably arose. Darlington's erroneous conclusions are probably due in part to his ignorance of the fact that these species are usually self-sterile.² Isolated specimens in gardens or greenhouses cannot be made to set seed. Moore (1917) had previously reported the fact, and we have been unable to obtain seed from self-pollination of any of the plants we have under cultivation, though they set seed readily in cross-pollinations.

There are two ways in which Darlington's hypothesis can be tested. We have evidence on both points.

¹ It should be remembered that Darlington includes not only the closely related species *T. reflexa*, but also the southwestern low-growing species *T. bracteata*, *T. humilis*, etc., as varieties and sub-species of "*T. virginiana* L. (U. S. A.)."

² On p. 272 and again on p. 274 he uses the hypothesis of "*continued self-fertilization*" to explain his results.

I. SEED PRODUCTION.

Prolonged search during the fruiting season failed to reveal a plant which was not producing seeds. No doubt such plants do exist, but none was found among the several hundred we examined. Most of the plants we examined were setting abundant seeds and many of the populations included young seedling plants.

II. VARIABILITY BETWEEN PLANTS IN WILD POPULATIONS.

The morphological consequences of vegetative and sexual reproduction are so different that a careful morphological analysis of wild populations will yield critical evidence. Such an analysis will do more than demonstrate merely the occurrence or non-occurrence of vegetative reproduction. It will make possible an evaluation of the relative importance of sexual and vegetative reproduction in maintaining the species. If vegetative reproduction is of any considerable importance its existence will be demonstrated in three different ways:

(1) The persistence of an actual organic connection between the parent plant and its vegetatively derived offspring.

(2) the frequent occurrence of morphologically indistinguishable plants which had originated vegetatively from a single individual, but in which the connection had died out or had been severed.

(3) The occasional appearance of a single, isolated individual.

These are all probably self-evident, except perhaps (3) which follows from the fact that if a species reproduces actively from seeds as well as by vegetative means, a single individual introduced into a virgin locality will soon be surrounded by seedlings, which will vary among themselves.

It would not have been surprising to have found any or all of these conditions in *Tradescantia* since all three are commonly met with among the Monocotyledons. An entire meadow is occasionally colonized by a single clone of *Iris* nor is it uncommon in that genus to find neighboring plants with no remaining evidence of an actual physical connection, between whose flowers there are no greater differences than exist on either plants. On all three of these points, however, we have evidence that vegetative reproduction is of minor importance in the tetraploid *T. reflexa*.

(1) Among the plants of *T. reflexa* which we studied there was never the slightest evidence of an organic connection between neighboring plants. Spreading by rhizomes was limited to a compact area around the parent stem.

(2) In not a single instance did we find two neighboring plants which could not be easily distinguished (see Table 4 and text fig. 2). Transplant experiments with a few of these types showed

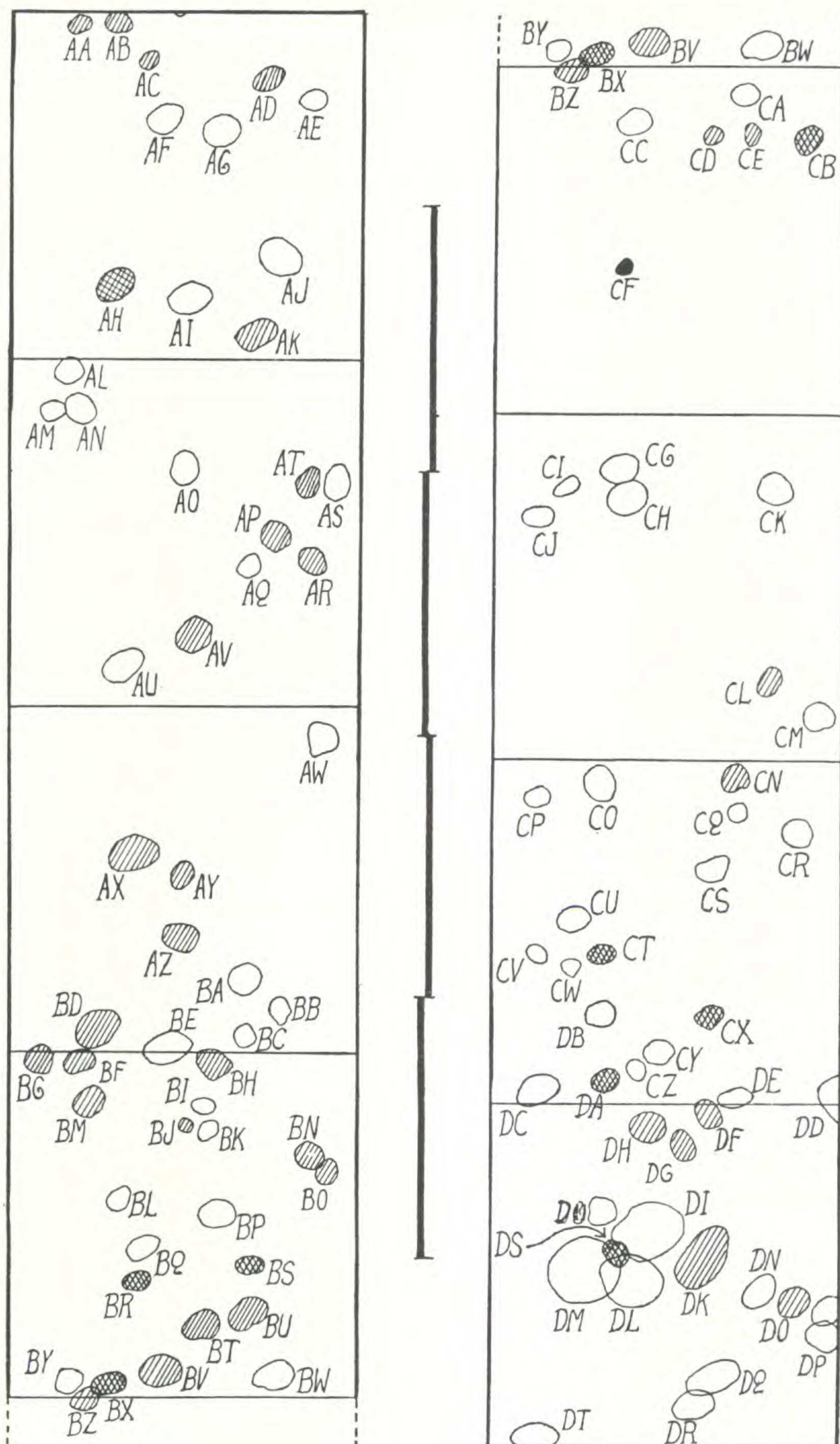


Figure 2. A belt transect of eight two-meter quadrats at Algonquin, Missouri. Each circle represents a single clone and the area is roughly that of the crown at the time of flowering. Unshaded plants bore blue flowers, diagonal lines represent blue-magenta flowers, cross-hatching magenta, and solid black represents pink. Further description of the plants in Table 4. The divisions of the scale represent five feet.

that these individual differences were largely inherent and persisted under cultivation.

(3) We never found an isolated clone of *T. reflexa*. In every case if there was one plant there were from a dozen to several thousand other plants nearby. Although a clone of *T. reflexa* will persist for years under cultivation, gradually increasing in size, the largest we found in nature had a crown under three feet in diameter, and the crowns of the majority of wild plants are less than six inches across. As a matter of fact, the diploid species *T. bracteata* is more vegetatively vigorous than its tetraploid relative and often produces clones over two feet in diameter.

A DETAILED STUDY OF ONE COLONY OF *T. REFLEXA*

A typical colony of *T. reflexa* was chosen for intensive study and a part of the data collected are presented in Table 4 and figure 2. The colony occupied two or three acres along the Missouri Pacific right of way near the Algonquin suburban station in Webster Groves, Missouri. Eight two-meter quadrats were laid out in one belt transect. The individual clones were scored for height, pubescence of sepals and ovary, flower color, and number of stems.

While the variation in flower color and in pubescence was somewhat greater than we usually found, it was by no means exceptional. The variation in height of stem and size of clone was, on the other hand, less extreme than the average. The seed capsules of *Tradescantia* explode when ripe and discharge their seeds over a radius of a few feet. If a colony is left undisturbed there would soon be a tendency for seedlings to show greater resemblances to neighboring plants than to the colony as a whole. There is some circumstantial evidence from this colony and from other colonies that in this way seedlings tend to grow up around a prolific mother plant and form small "neighborhoods" in which adjacent plants resemble one another more closely than they do the colony at large. It will be seen from figure 2 that plants of different colors are not distributed at random. This was even more evident when the whole colony was examined. Although no two neighboring plants were identical there was often a "family resemblance" between them, and pink and magenta flowered plants tended to occur in groups.

A SURVEY OF SOUTHWESTERN TRADESCANTIAS

In addition to the material which we collected personally we were enabled through the kindness of Dr. B. C. Tharp of the University of Texas and Dr. D. W. Moore of the University of Arkansas to make a preliminary survey of the *Tradescantias* from those regions.

TABLE 4

CLONE	HEIGHT OF STEM	PUBESCENCE ON		FLOWER COLOR (APPROXIMATE)	No. OF STEMS
		SEPALS	OVARY		
AA	short	tufted at apex	glabrous	medium magenta	UNLESS OTHERWISE INDICATED THERE WAS ONE STEM PER CLONE
AB	short	scattered	glabrous	medium magenta	
AC	short	scattered	a few hairs at base of style	medium magenta	
AD	medium	tuft at apex	glabrous	medium magenta	
AE	medium	scattered	hairs at base of style	medium blue	
AF	short	scattered	glabrous	blue	
AG	medium	scattered	glabrous	blue	
AH	medium	scattered	hairs at base of style	magenta	
AI	medium	tuft at apex	glabrous	blue	
AJ	medium	lightly scattered	glabrous	blue	
AK	medium	lightly scattered	glabrous	medium magenta	
AL	medium	lightly scattered	glabrous	dark blue	
AM	medium	lightly scattered	glabrous	dark blue	
AN	medium	lightly scattered	glabrous	dark blue	
AO	medium	lightly scattered	glabrous	dark blue	
AP	medium	lightly scattered	glabrous	medium magenta	
AQ	medium	lightly scattered	glabrous	blue	
AR	medium	lightly scattered	glabrous	medium magenta	
AS	short	lightly scattered	glabrous	blue	
AT	medium	lightly scattered	glabrous	medium magenta	
AU	tall	tuft at apex	glabrous	blue	three stems
AV	medium	tuft at apex	glabrous	medium magenta	
AW	medium	tuft at apex	glabrous	blue	
AX	medium	tuft at apex	glabrous	medium magenta	
AY	short	scattered	glabrous	medium magenta	
AZ	tall	scattered	glabrous	medium magenta	
BA	tall	tuft at apex	glabrous	blue	
BB	medium	tuft at apex	glabrous	blue	
BC	short	scattered	glabrous	blue	
BD	short	scattered	glabrous	medium magenta	
BE	past blooming				
BF	medium	scattered	glabrous	medium magenta	
BG	medium	tuft at apex	glabrous	medium magenta	
BH	tall	tuft at apex	glabrous	medium magenta	
BI	medium	lightly scattered	hairs at base of style	light blue	
BJ	medium	tuft at apex	hairs at base of style	medium magenta	
BK	medium	tuft at apex	glabrous	medium blue	
BL	short	scattered	glabrous	blue	
BM	medium	scattered	glabrous	medium magenta	
BN	medium	scattered	glabrous	medium magenta	
BO	medium	scattered	glabrous	medium magenta	
BP	medium	scattered	glabrous	blue	
BQ	medium	scattered	glabrous	blue	
BR	medium	tuft at apex	glabrous	magenta	
BS	medium	tuft at apex	glabrous	magenta	
BT	medium	tuft at apex	glabrous	medium magenta	two stems
BU	short	scattered	glabrous	medium magenta	
BV	medium	scattered	glabrous	medium magenta	
BW	medium	scattered	glabrous	blue	two stems
BX	medium	tuft at apex	glabrous	magenta	
BY	medium		through blooming		
BZ	tall	scattered	glabrous	blue magenta	
CA			Seedling		
CB	tall	scattered	glabrous	medium magenta	

TABLE 4—Continued

CLONE	HEIGHT OF STEM	PUBESCENCE ON		FLOWER COLOR (APPROXIMATE)	NO. OF STEMS
		SEPALS	OVARY		
CC	tall	scattered	glabrous	dark blue	four stems
CD	medium	scattered	glabrous	dark blue magenta	
CE	medium	tuft at apex	glabrous	medium magenta	
CF	short	tuft at apex	hairs at base of style	pink	
CG	medium	tuft at apex	glabrous	blue	two stems
CH	medium	scattered	glabrous	dark blue	
CI	tall	tuft at apex	glabrous	dark blue	
CJ	tall	tuft at apex	glabrous	dark blue	
CK	medium	scattered	glabrous	light blue	three stems
CL	tall	tuft at apex	glabrous	dark blue magenta	
CM	short	tuft at apex	glabrous	blue	
CN	short	tuft at apex	glabrous	dark blue magenta	
CO	tall	tuft at apex	glabrous	dark blue	three stems
CP	medium	scattered	glabrous	dark blue	
CQ	tall	scattered	glabrous	dark blue	
CR	medium	tuft at apex	glabrous	dark blue	
CS	medium	scattered	glabrous	blue	four stems
CT	short	scattered	glabrous	magenta	
CU			Seedling		
CV	short	scattered	glabrous	blue	
CW	medium	tuft at apex	glabrous	blue	seven stems
CX	short	tuft at apex	glabrous	magenta	
CY	medium	scattered	glabrous	blue	
CZ	medium	scattered	glabrous	blue	
DA	medium	scattered	glabrous	dark magenta	large clone
DB	short	tuft at apex	glabrous	light blue	
DC	tall	tuft at apex	glabrous	blue	
DD	tall	tuft at apex	glabrous	medium blue	
DE	medium	scattered	glabrous	blue	large clone
DF	short	scattered	glabrous	blue magenta	
DG	short	tuft at apex	glabrous	blue magenta	
DH	short	tuft at apex	glabrous	blue magenta	
DI	tall	scattered	glabrous	light blue	large clone
DJ					
DK	medium	scattered	glabrous	blue magenta	
DL	medium	scattered	glabrous	dark blue	
DM	tall	tuft at apex	glabrous	light blue	five stems
DN	tall	tuft at apex	glabrous	dark blue	
DO	medium	scattered	glabrous	magenta blue	
DP	tall	scattered	glabrous	blue	
DQ	medium	tuft at apex	glabrous	blue	large clone
DR	medium	scattered	glabrous	blue	
DS	medium	scattered	glabrous	magenta	
DT	tall	scattered	glabrous	medium blue	
DU	medium	scattered	glabrous	light blue	seven stems

The material was forwarded just before it came into bud and was grown in the greenhouse, where material for smears was obtained. The following species were examined: (with the exception of *T. texana* the determinations are those made by Dr. Tharp.)

	P M C	POLLEN MITOSIS
<i>T. humilis</i>		
plant A.....	n = 6	—
plant B.....	n = 6 + f	n = 6 + f
<i>T. edwardsiana</i> ¹	—	n = 6

¹ *Tradescantia edwardsiana* Tharp in *Rhodora*, xxxiv. 57, fig. 1 (1932).

	P M C	POLLEN MITOSIS
<i>T. hirsuticaulis</i>	—	n = 6
<i>T. texana</i>	n = 6	n = 6
<i>T. gigantea</i>		
plant X.....	n = 6 + f	n = 6 + f
plant Y.....	n = 6	n = 6
<i>T. occidentalis</i>	—	n = 6
<i>T. sp. (reflexa ?)</i> from Texas.....	—	n = 6
<i>T. sp. (reflexa ?)</i> from Arkansas.....	—	n = 6

It will be noticed that whereas two of the species in the St. Louis region were tetraploids, all of the material from the southwest was diploid. One of the species from Texas and all of the plants from Arkansas were very similar to *T. reflexa* as it occurs in Missouri; just how similar could not be determined since the southern material was forced into bloom under abnormal conditions. If these plants do not belong to *T. reflexa*, they must certainly form a very closely related species. Since the Missouri and other northern material of *T. reflexa* was all tetraploid it is therefore quite possible that polyploidy is intraspecific in *Tradescantia* and that diploid and tetraploid races may occur within the same species.

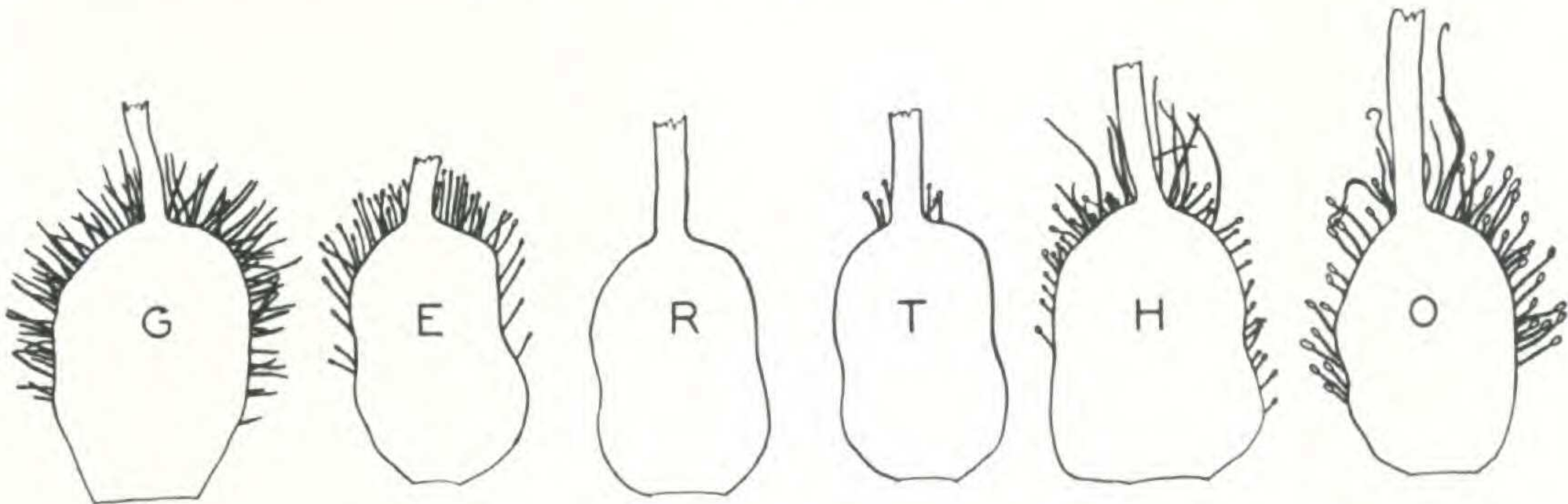


Figure 3. Ovaries of six species of *Tradescantia* from the neighborhood of Austin, Texas. Drawn, greatly enlarged, with camera lucida. From left to right: G; *T. gigantea*; E; *T. edwardsiana*; R; *T. reflexa*; T, *T. texana*; H, *T. hirsuticaulis*; O, *T. occidentalis*.

It is particularly interesting that the tetraploid *Tradescantias* should be more northerly than the diploids. Sax (1931) has reported in the closely related genus *Rhoeo*, the artificial production of tetraploids by exposure to low temperatures. A similar geographical position for tetraploid races and species to the north of their diploid relatives has been reported for a number of genera. Hagerup (1928) collected six such cases in the *Bicornes* alone and has recently summarized the evidence on polyploid geographical races (1932). It is particularly interesting that Mangelsdorf and Reeves (1931) working with another American monocot of tropical affiliations (*Tripsacum dactyloides*) have found that the plants collected in Texas are diploids while those from the north and east are tetraploids.

It may be well in passing to point out that the differences between the seven diploid species from Texas are quite as great, on the whole, as are those between the three Missouri species. Polyploidy here, as elsewhere, has introduced complexity into inter-specific relationships, but species differentiation has taken place to an even greater extent in regions where polyploidy was absent.

Table 5 summarizes the outstanding differences between these species. Camera lucida outlines of their ovaries are shown in figure 3. While instances of inter-specific hybridization are not unknown, most of these Texas species are kept apart by habitat differences and maintain themselves as recognizable units over a wide area.

TABLE 5—A TABULAR COMPARISON OF SPECIES DIFFERENCES IN TEXAS AND MISSOURI

SPECIES	STEM	FLORAL LEAVES	PUBESCENCE ON		
			LEAVES	SEPALS	OVARY
TEXAS SPECIES:					
<i>T. texana</i>	short, weak branched	long, equal	long, vil-lous	dense, glandular	a few glandular hairs at top
<i>T. gigantea</i>	tall	short, sub-equal, dense-ly pilose	glabrous	dense, non-glandular	very dense, non-glandular
<i>T. hirsuticaulis</i>	tall	short, unequal	hirsute	sub-gland-ular	glandular and non-glandular
<i>T. humilis</i>	short	unequal	hirsute	glandular	dense, gland-ular
<i>T. occidentalis</i>	slender	slender	glabrous	scattered glandular	glandular and non-glandular
<i>T. sp. (reflexa ?)</i>	medium	long, unequal	glabrous	glabrous except for tuft at apex	glabrous
MISSOURI SPECIES:					
<i>T. reflexa</i>	medium to tall	long, unequal	glabrous	glabrous except for tuft	glabrous
<i>T. bracteata</i>	short	very long, subequal	scattered, glandular	glandular	dense, glandular
<i>T. pilosa</i>	tall zig-zag	sub-equal	scattered, pilose	glandular pilose	scattered, glandular

CONCLUSIONS

It should be remembered that the following conclusions are little more than working hypotheses and that they are put forward tentatively at the end of our first year of intensive work. In begin-ning this study we had as our objectives (I) the description of the species of *Tradescantia* as they occur in nature and (II) the evalua-tion of the evolutionary processes which are taking place in them at the present time.

I. As regards the description of these species and their separation and classification we feel that they are a difficult group but by no means an impossible one. Their inter-specific relationships are not nearly so intricate as are those of such genera as *Rubus* and *Crataegus*, for instance. In this connection we have found the pubescence on the ovary a particularly useful character because it varies so little within species. A colony of *Tradescantias* may vary strikingly in size and general aspect from plant to plant and yet the pubescence on the ovary will be the same throughout the colony. The pubescence also varies widely from species to species. It may be dense, or sparse, or restricted to one part of the ovary, or completely wanting. The hairs may be long or short, and glandular or non-glandular. Used in connection with other characters it is very helpful in working out specific relationships.

II. In evaluating the evolutionary processes which are taking place at the present time, we have evidence on three, fragmentation, polyploidy and hybridization.

FRAGMENTATION.

In every species in which we were able to examine a number of different plants, we found individuals with supernumerary fragment chromosomes. That is, in addition to the normal chromosome complement for the species, these individuals had one or two fragment chromosomes, much smaller than the rest (Plate 45, figs. A, K). In at least two cases these fragments paired regularly at the reduction division and were distributed to all the germ cells. We found fragments occurring with roughly the same frequency in all the species which we investigated. If, as seems probable, they affect the external morphology of those plants which bear them, we have here a unique case in which one of the causes of variation within species is not itself effective in forming new species. Had it been so we should have found entire species or races which were characterized by the possession of supernumerary chromosomes.

POLYPLOIDY.

In these species of *Tradescantia* polyploidy is apparently intra-specific, with consequent division of those species possessing it into diploid and tetraploid races. It apparently allows a northern extension of the range in those species in which it has occurred. It increases manifold the variation between individual plants. Its "blurring" effect upon variation in flower color can actually be demonstrated and a similar effect upon morphological characters is inferred from the peculiar variability of the tetraploid species, *T. reflexa* and *T. virginiana*. In the section of the genus which we have

studied, polyploidy does not occur at the center of specific diversity but is instead characteristic of the northern periphery of the genus. It must therefore be of relatively minor importance as a factor in originating new species though it multiplies the complexity of *inter-specific* and *intra-specific* relationships.

HYBRIDIZATION.

Although this undoubtedly occurs we have as yet found little actual evidence for it. The colony from Hillsboro, described above, may perhaps have resulted from previous hybridization between *T. reflexa* and *T. bracteata*. An apparent example of hybridization between *T. humilis* and *T. reflexa* has just been discovered in the vicinity of Austin, Texas.

SUMMARY

Three species of *Tradescantia* are common in the region about St. Louis, Missouri, two tetraploid species *T. reflexa* and *T. pilosa*, and one diploid species, *T. bracteata*. White-flowered and pink-flowered forms are frequent in *T. bracteata* while in the two tetraploid species they are rare. Furthermore various intermediate magenta shades are common in the tetraploid *T. reflexa* but are not found in *T. bracteata*. This is shown to follow logically from the fact that *T. reflexa* is practically an auto-tetraploid.

Darlington's assumption of highly developed vegetative reproduction in tetraploid *Tradescantias* is found to be without any foundation in fact.

The inter-clonal variation of a single colony is presented in detail.

Seven species of *Tradescantia* from eastern Texas were found to be diploids.

The evolutionary importance of fragmentation, polyploidy, and hybridization is briefly discussed.

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